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OCEANUS

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EDITOR: JAN HAHN

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AMONG the pleasanter memories of most ocean voyages are those of porpoises playing about the vessel. Whether one's interest be esthetic or merely scientific, it is easy to pass a great deal of time admiring the smooth grace with which these animals swim. In our profession we tend to temper admiration with investigation. How do these beasts swim so fast, and how fast? How do they time their breathing to their brief surfacings? How do they keep station? How do they avoid collision with each other or with the vessel? Are their squeals and barks useful for such purposes? How do they make these sounds, and how do they hear? Many a scientist has struggled with these and other questions, and several of them are now being studied at the Woods Hole Oceanographic Institution.

Our handsome cover photograph was made by Jan Hahn six years ago in the northern Gulf of Mexico. These spotted porpoises (professors and other landsmen say "dolphin", but seamen say "porpoises") are members of a large group (the genus Stenella) which is found all around the world, usually in the lower latitudes. They are not easy to tell apart, especially at sea, in spite of the conspicuous pattern of spots. In our photograph this pattern is streakily distorted by the wavy sea surface, in which is reflected the overhanging bow of our "Atlantis". The porpoises are easing along at about nine knots, keeping pace with the vessel.

W. E. S.

EDITORIAL

Autumn and Winter 1956 - 57, Vol. V, Nos. 1 and 2.

THERE are vogues in oceanography as well as in many other fields. For the first few years after World War II the Gulf Stream System was one of the most interesting fields of investigation here at Woods Hole; the instruments and methods developed during the war, together with the use of the loran navigation system, made it possible to discover exciting new information about the Stream. A little later deep echo sounders and seismic techniques provided an extraordinarily great amount of new knowledge concerning the earth, its geological formation, the development and possible origin of continents and ocean basins. How much life the ocean can produce then became the subject of a heated controversy, a controversy by no means solved. In more recent years the marine meteorologists, equipped with airplanes, a host of new devices and reams of mathematical equations, are much in the foreground.

We do not mean to imply that the subjects quickly become worn out, that all the answers become known, but rather that new techniques, new instrumentation, and new ideas spring up fairly quickly bringing surprising results and then, at least as far as public interest is concerned, slow down into a steady evaluation of the obtained results and the long, painful drag delving into the particulars of the findings and attempts at answering the host of new questions which the few answers have provided.

Oceanography is an exciting subject; one feels part of discovery and exploration, as much so as any explorer of old. It is our hope that the Associates will feel partners in this Enterprise and will enjoy watching the developments.

R. V. Atlantis at sea.

The Recent Göteborg Meetings

by C. O'D. Iselin

In September 1955 an **ad hoc** group of oceanographers met in Brussels to plan the research vessel operations during the International Geophysical Year (IGY). This series of meetings produced the surprising information that about 50 vessels from at least 15 nations were scheduled to take part. Also, at this time, we had our first modern discussions with Russian oceanographers whose research vessels are much larger and more numerous than those of any other nation.

Since the Brussels meeting several smaller international meetings of oceanographers have been called to consider regional programs, notably for the North Pacific and for the northern half of the North Atlantic.

Beginning on January 15, 1957 a week-long series of discussions was held at the Oceanographic Institute at Göteborg, Sweden, to review and coordinate the world-wide oceanographic effort during IGY, and to discuss various proposals for continuing cooperative programs. Some 51 oceanographers and observers from various international organizations were present at the outset and more arrived as the week progressed. The original Brussels group was much smaller and it reported to SCAGI (Special Committee for International Geophysical Year), which in turn is responsible to ICSU (International Committee on Scientific Union). The Göteborg meetings began under the same auspices. Dr. G. E. R. Deacon again acted as secretary, Colonel G. Laclavère, in addition to making many of the arrangements, provided the liaison with SCAGI and, in the absence of Rear Admiral E. H. Smith, I found myself having to act as chairman. It is the policy of SCAGI to turn over the various IGY programs to the available permanent international organizations. Here we ran into the chronic difficulty that besets everyone who tries to organize oceanography. It includes many scientific disciples so that several international bodies can claim to have some jurisdiction.

The principal business was accomplished without difficulty. Under the leadership of Dr. G. Böhnecke, and through the meetings of the International Council for the Exploration of the Sea, the program of the many ships planning to operate in the northern North Atlantic had been notably improved during the past year. Another important new feature is that three countries now expect to send expeditions to the Indian

Ocean, which at the time of the Brussels meeting seemed likely to be entirely neglected. Plans for the exchange of data and for the interchange of seagoing scientists were further developed. The almost unanimous conclusions of the first three days of discussions were summarized in 18 resolutions. It was not all work, for the proverbial Swedish hospitality also kept our evenings busy.

The next such meeting will be held at Toronto in September when it is expected that a continuing IGY coordinating committee will be appointed by the Association of Physical Oceanography (APO) and thus report to higher bodies through the International Union of Geodesy and Geophysics (IUGG). As mentioned above, this only takes care of part of modern oceanography. A number of important subjects, for example the expected radioactive contamination of the sea, are in danger of remaining orphans. Thus, it was proposed that a new long-range planning group known as SCOR (Special Committee on Oceanographic Research) come into being. In fact, the Executive Board of ICSU had already designated a bureau of four eminent oceanographers headed by Dr. R. Revelle to get SCOR started. The fourth day at Göteborg was largely devoted to discussions of what seemed to some a conflict between the responsibilities of APO and SCOR. It was also evident that at higher echelons there was some rivalry as to how best to capitalize on the oceanographic momentum that will be generated by IGY. My own view of the matter is that we are in danger of having more international committees in oceanography than there are qualified people with the time to serve on them.

What seemed clear to me, at any rate, was that under present circumstances the expense of travel is in danger of preventing the younger oceanographers, who in any case will have to carry out the work at sea, from having a voice in international meetings. I hope that we at Woods Hole can help to correct this undesirable situation by inviting as many promising oceanographers as possible to visit us next summer in advance of the meetings at Toronto. The SCOR group has also been invited to hold its next meeting at Woods Hole after the Toronto meetings. By this time, presumably the remaining conflicting interests of the "alphabetical soup" of unions and committees will have been resolved.

The final two days of the Göteborg meetings were devoted to technical discussions of radioactive waste disposal problems. So far as I know, this was the first large international meeting of oceanographers devoted to this considerable subject. It is not likely to be the last. Dr. B. H. Ketchum made a very able summary of the Institution's research program which is one of the most basic in this new area.

The encroaching sea is studied photographically from the PBY, flying thousands of miles along the Atlantic seaboard. Here, the changing strands of the southerly tip of Nauset Beach, Cape Cod, are shown.

William S. Richardson

Airborne Oceanographers

Aircraft have become a definite part of our research fleet.

THE Woods Hole Oceanographic Institution in cooperation with the U. S. Navy Bureau of Aeronautics and the Office of Naval Research has been operating a PBY-6A aircraft for about five years. The use of this and other aircraft by members of the Institution staff for research in meteorology and cloud physics has been described in previous issues of this magazine*. In addition, the PBY has been used extensively for magnetic and gravity surveys and studies of coast erosion. It is the purpose of this article to describe the use of aircraft in physical oceanographic research.

To review briefly the history of the use of aircraft by oceanographers and others who work at sea, we may note that the first use was probably by fishermen for spotting fish schools. At the present time there are companies whose sole occupation is to provide this service for the various fishing fleets, and in the Pacific coast tuna fishery a small float plane is often a regular part of a fishing vessel's equipment. Our staff ichthyologists occasionally fly for this purpose and random fish sightings by our aircraft often excite considerable local interest. The International Ice Patrol began aircraft reconnaissance for icebergs in 1946 and continues it at the present time. Considerable information on the motion of the surface water in the area

* See: Trade Winds and Trade-Wind Clouds, Oceanus, Vol. IV, No. 3.

east of Newfoundland can be obtained from their data. Similarly, the U. S. Navy Hydrographic Office uses aerial reconnaissance to determine the time of the breakup and reformation of sea ice in the Labrador Sea. L. V. Worthington and John F. Holmes of our staff used several planes as vehicles to land on the frozen Arctic Ocean during Operation Ski-jump in 1951 and 1952. Standard oceanographic measurements were made through holes in the ice. In 1950, Operation Cabot, a multiple-ship survey of the Gulf Stream, saw one of the first uses of aircraft in support of research vessels working on a physical oceanographic problem. By flying the aircraft to follow the visible edge of the Gulf Stream, William V. Kielhorn was able to provide the ships with a fairly synoptic picture of the location of the edge which, in the early stages of the operation, was used to plan the ship's movements. Incidentally the aircraft also provided an important service to this operation when it parachute-dropped new Bathythermographs to one of the research vessels which had lost its supply of this vital instrument.

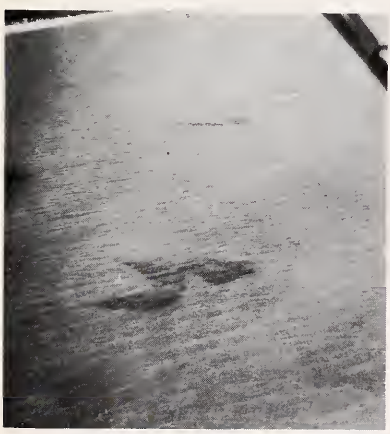
Physical Work

In all of this work — with the exception of Ski-jump — the problem is one of search using the human eye and radar as the primary instruments. With the acquisition of the PBY, work was begun to provide other physical measurements from the airplane. One of the early attempts was a radar swell height recorder developed by Holmes. This instrument proved unsatisfactory because of the difficulty in maintaining an exact flight altitude. Concurrently with this work, and extensive instrumentation by the meteorologists, Henry Stommel and his co-workers developed a radiometer for measuring the sea surface temperature from the aircraft. This instrument was used in 1953 for aerial reconnaissance of the edge of the Gulf Stream. These measurements showed that the thermal gradient on the surface at the edge of the Stream was in some areas much more abrupt than the ship observations indicated and in other areas very diffuse and gradual. Flights were made covering several hundred miles of the edge in a single day and these indicated a shingle-like overlapping structure to the surface discontinuity*. In general the edge follows a meandering pattern as indicated by the

Dr. William S. Richardson has been concerned with temperature measurements by airborne radiation thermometer, physical optics of sea water, and the development of sensitive shipborne temperature measurement devices. He came to the Institution in 1952 from the Mellon Institute of Industrial Research.

* See illustration page 13, Oceanus, Vol. IV, No. 4.

ship data, and a combined aerial reconnaissance and drift experiment by the ATLANTIS showed that the aircraft could plot the edge to within a few miles of what the ship considered to be the axis of the current. Of course the ship is capable of studying the current in depth and thus obtains considerably more data as to its structure. However, it requires many days for the ship to cover a few hundred miles while the aircraft can delineate the major direction and changes in directions over the same distance in a few hours. Thus the two attacks are complimentary. In addition to the Gulf Stream work the radiometer has been used to detect other currents. Also, because of its high sensitivity, it has been used to study small-scale fluctuations in sea-surface temperature, particularly in the Caribbean area. In this case it has been possible to correlate warm patches on the surface with individual



Schools of menhaden are spotted for the fishing fleet by small planes off the North Florida coast.

trade-wind cumulus clouds, thus suggesting an origin of such clouds. Incidentally, as

Through the rigging of the "Atlantis" the PBY is seen flying by during a Gulf Stream cruise.

the radiometer was improved it soon developed such high sensitivity that none of the shipborne temperature equipment was capable of providing data for comparison, so it served as an impetus for the development of more sensitive thermal recorders for the ships.

Another method which permits the airborne oceanographer to make physical measurements in the water is the use of buoys. Various small expendable buoys have been used for specific problems and recently larger drifting buoys tracked by the airplane have been used by Dean F. Bumpus*. The possibilities of buoys are almost unlimited and the present developments by Robert G.

* See: Drift Bottles are Getting Bigger, Oceanus, Vol. IV, No. 4.

Landed on the icepack of the Arctic Ocean, L. V. Worthington prepares to lower a Nansen bottle through a hole cut into the ice. Hot air blows through the pipe above his head to warm his bare hands.

Walden and David D. Ketchum have shown that reasonable reliability is easily achieved. The present system is to use a buoy with a receiver and a transmitter in it. The aircraft flies out to the approximate location of the buoy and sends out a radio signal which triggers the receiver in the buoy and causes it to transmit. The plane then uses radio-direction finding equipment to locate the buoy, and if the buoy's transmissions are properly modulated the airplane can record almost any property of the water in which the buoy is located. The buoys may be either anchored or drifting. They are economically very attractive since they can occupy a station for long periods of time and the aircraft can cover a large number of them scattered over a wide area at costs small compared to comparable ship time. The question of whether the buoys should have enough power (be big enough) to transmit directly to a shore laboratory, thus eliminating the aircraft's part, is an economic one. At present and in the foreseeable future we may expect the plane to be a very useful mobile listening station.

Aircraft Operation

It may be appropriate at this point to discuss briefly the economies and operation of aircraft. For a medium-sized two-engine aircraft (two engines are mandatory for safety in long over-water flights) such as the PBY or the R4D(DC-3) which will soon replace it, it costs approximately one hundred dollars per hour to fly. This figure is based on 600 hours' use per

year. Since a large portion of the costs are fixed, the hourly rate decreases as more use is made of the plane. Maximum flight time per day is limited by human fatigue and is something like twelve to fourteen hours. For day-in, day-out operation seven hours per day is reasonable. Comparison with ship costs is not particularly valid since the function and capabilities of aircraft and ships are so different. However, we may note that our ships cost about fifty dollars per hour to operate and since the speed differential between the plane and our ships is about 15 to 1, the aircraft is about seven times cheaper per mile than the ship for operations involving simple search and tracking.

An early attempt at using aircraft for the study of ocean waves was mentioned above. A more recent study by Wilbur Marks, Project SWOP, utilized two aircraft taking simultaneous pictures of the sea surface. These pictures were contoured by stereogrammetric techniques and provided a very elegant three-dimensional picture of the surface. Munk and Cox of the Scripps Institution of Oceanography have used aerial photographs of the sun glitter pattern on the sea surface for similar measurements. The relationship of ocean waves to the sea clutter which appears on aircraft radar is now under investigation by Harlow G. Farmer, Jr. This work involves wave measurements by ships or buoys in conjunction with radar clutter measurements by aircraft of the Naval Research Laboratory. It is conceivable that when this phenomena is better understood the process may be reversed and the clutter measurements used to study waves. These measurements of ocean waves and the movements of the surface layers are of vital interest to those who work in search and rescue at sea and particularly to those concerned with the landing of large seaplanes in the open ocean.

To the best of the author's knowledge, Gifford C. Ewing of Scripps Institution of Oceanography is the only oceanographer who flies his own plane for physical oceanographic research. He has been working for several years on the problem of understanding the slicks and streaks which are so well known to those who fly over water. These changes in the appearance of the surface are caused by convergences and divergences in the surface layers, and his speculations and laboratory experiments on the origins of the motions have been very illuminating.

The Future

Looking into the future, what extensions in the use of aircraft in oceanography may we expect? In addition to surface temperature measurements we may some day be able to measure the other important variable, surface salinity. Such a determination is theoretically possible by measuring the reflectivity of the surface for high frequency radio waves; in practice this may be a very different measurement to make. Another advance we may hope for is the measurement of surface water movement by Doppler radar. At present this type of radar is used for navigation of aircraft to provide a ground speed. Obviously if the "ground" is moving, the ground speed will be in error by the amount of this motion and if the aircraft can be navigated correctly by other means, this motion could be obtained by difference. Finally, it behooves the oceanographer to keep a sharp eye on other research establishments who are engineering systems for towing equipment in the water from aircraft, helicopters, and blimps. Their success, or the successful development of an open-ocean seaplane may provide an important break-through in the use of aircraft in oceanography. In any case it appears that the airplane is in the oceanographic business to stay and we may look forward to its extended use in the future. Finally, we may note that in addition to operating the PBY and the smaller Stinson aircraft the Woods Hole Oceanographic Institution pays annually about $25,000 for commercial airborne transportation, indicating that oceanographers here are indeed airborne.

The only oceanographic pilot in the world, Norman G. Gingrass has captained our PBY since 1952.

Two species of young dolphin fish (Coryphaena) have been identified by Dr. Robert H. Gibbs of our staff.

It is not commonly known that two species of this prized game fish exist. The one shown at the top, and at lower right, is the young of the dolphin usually taken by hook and line. The other species is the "little dolphin", rarely taken by anglers but strangely enough far more common in collections of young fish than the "common dolphin."

Many people doubted the existence of two species. They are now being described by Dr. Gibbs for publication in a scientific journal with the aid of detailed drawings being prepared by Mr. Gail Paisley of our staff.

This is but one of the results of a volunteer program on board our ships to take as much "wildfire" as possible by dipnetting while our ships are hove-to. During the daytime someone is usually looking over the side while at night strong lights are used to attract marine life.

Gifts and Grants

Two grants were received from the National Science Foundation. One, in the amount of $20,000. for support of research entitled "Nitrogen Cycle in Coastal Sea Waters" under the direction of Dr. Bostwick H. Ketchum for a period of approximately three years. The other, in the amount of $42,000. for support of research entitled "Basic Productivity of the Sea" under the direction of Dr. John H. Ryther for a period of approximately three years.

Associates News

Tuna Ground Chart

A three dimensional bathymetric chart of Soldier's Rip off Westport, Nova Scotia was presented on behalf of the Associates to the Westport Tuna Guide's Association last fall. The mounted chart was made by Mr. R. Miller of our staff and shows in detail the bottom configuration of the famous tuna fishing grounds. Associate S. Kip Farrington who coordinated the presentation, handed the chart over to the Prime Minister of Nova Scotia at the Awards Dinner of the International Tuna Cup Matches. Hung in the clubhouse of the Westport Tuna Guide's Association, the chart received widespread interest among the international group of big game fishermen present.

Gifts and Grants

FOR the second time a grant of $3,500. was received from the Esso Education Foundation. In a letter accompanying the grant, Mr. Eugene Holman, Chairman of the Foundation, stated that — "these companies believe that business should share with other citizens the responsibility of supporting private U. S. colleges and universities so that they might continue to share in meeting the increasing demands of our society, which requires even higher intellectual standards for larger numbers of its citizens".

A contribution was also received from TI-GSI Foundation, on behalf of the Texas Instruments Incorporated, Geophysical Service Inc., and affiliated companies.

New Industrial Associates

The Dow Chemical Company, Midland, Michigan
Freeport Sulphur Company, New York, New York
Isbrandtsen Company, Inc., New York, New York
Munitalp Foundation, Inc., New York, New York
Sylvania Electric Products, Inc., New York, New York

New Life Members

WE are also pleased to announce that Mr. and Mrs. Alan C. Bemis, Mr. and Mrs. George S. Frierson, Jr., Mr. and Mrs. J. Seward Johnson and Mr. and Mrs. John Parkinson, Jr. have become Life Members of the Associates of the Woods Hole Oceanographic Institution.

How cold is a whale's tail?

By John Kanwisher

Whales were chased off the Norwegian coast to determine how they regulate their temperatures.

WHALES are found in all seas from the tropics to the edge of the polar ice. They belong, along with man, to that group of animals called mammals which maintain their bodies at a high and nearly uniform temperature. Unlike many of these mammals which have fur for insulation the whale is bare-skinned, another of its similarities to man. One might wonder then how it keeps warm in icy polar waters when it is also at home in the tropics. Some species like the humpback and grey whales migrate yearly between these extremes; thus whales must somehow be able to vary their insulation in a manner analogous to our putting on and taking off clothes.

The rate of internal heat production which keeps the animals warm can also vary greatly. In a whale being chased, heat may be produced at ten times the rate in one swimming leisurely. Yet the animal cannot allow itself to become overheated any more than we can. At times the thermostatic controls in a whale must operate to conserve heat and at other times to discard it. Because of the great range of size between the small porpoises, which

are accorded full recognition as true whales by biologists, and a fin whale one may expect to find some interesting variations in the physics of how the different species handle the problem of thermal regulation.

The layer of blubber that covers most of the body can act as an effective barrier to heat loss, but the flippers and tail are relatively uninsulated. Yet, they must be supplied with blood the same as other parts of the body. This blood will become cooled while in these regions and might act as a serious chilling source when it returns to the deep body of the animals. Scholander and Schevill found structures in the circulatory system of small whales which they think can prevent this loss of heat. The arteries and veins are arranged in such a way that they form counter-current heat exchangers, much like that in a power plant where the heat of the outgoing flue gases is transferred to the incoming air. It appeared that in whales the heat of the warm blood from the deep body is used to warm the cool blood returning from the tail and flippers. By this means blood can be supplied to the uninsulated cold areas of the whale without losing large amounts of heat to the surrounding water.

The circulatory system also seemed well designed for the discarding of heat, which is probably necessary to prevent overheating in a fast swimming animal. The same authors found vessels which by-pass the heat exchangers. The blood flowing in this path is effective in cooling the entire animal. The flippers and tail of these small whales seem to work in the same manner as the radiator of an automobile to prevent overheating. The whales' temperature may be thermostatically controlled by varying the fractions of the blood flowing through the heat exchanger or the by-pass.

Up to this point this is all theory based on the structures found in dead animals. One would feel more convinced if confirmation could be had from measurements made on a live specimen. With this in mind I decided to attempt such temperature measurements on large whales. The approach was to take the data on a freshly killed animal. Because of the whale's large size these temperatures will be very close to those existing before death.

Fortunately, an instrument for such measurements proved to be no problem. At the time I happened to be making a device for Dr. Redfield to take temperature profiles in salt marshes. Simply by providing a sharp tip, the instrument made an excellent temperature-harpoon which could easily be pushed six feet into the flesh of a whale. Things are rarely so simple when one starts new work.

Since the large whales are fished commercially they turn out to be more available than small ones. Also, one can hardly deny a certain fascin-

With a powerful stroke of the tail, this porpoise jumps out of the water while overtaking the "Atlantis". Whales must be able to lose heat rapidly while swimming fast.

ation and adventure in an experiment involving these largest of all animals in which the heart alone weighs as much as six average men. An elephant will fit comfortably in the mouth of a blue whale.

The Chase

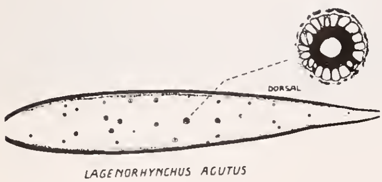
Off the Norwegian coast, whales are shot from small, fast boats and towed to a shore station for cutting-in and processing. This differs from the Antarctic where the entire operation is carried out at sea in large factory ships. This past fall I enjoyed the hospitality and enthusiastic cooperation of the whalers at Steinshamn on the Norwegian coast, where the whales are chased for their meat and have a market value of from $6,000 to $8,000. Against a backdrop of mountains and fjords we spent all the daylight hours of good weather scanning the sea for the telltale burst of spray made by a breathing whale.

Although I spent six weeks on the boat, due to bad weather and a poor season we were only able to make measurements on one animal, a 54-foot fin whale. It was not chased and was apparently killed immediately by the harpoon. Thus, the temperatures measured probably are close to those of a resting live animal.

We were able to make measurements in the abdominal cavity and surrounding body wall, along the peduncle or narrow part of the animal leading to the tail, and also in the tail itself. In addition we obtained the temperature in the abdominal cavity and muscle for twenty hours while the whale was towed to the shore station. From these measurements we hoped to get information on the effectiveness of splitting open the belly. This is done

to cool the animals and thus slow down putrefaction.

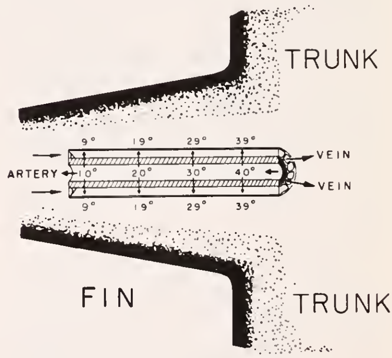
The deep muscle and body cavity of the whale had a uniform temperature of 35.6°C. This is within the range of variation found for other mammals and only one degree



A section near the base of the fin of a porpoise shows how each artery is surrounded by a channel of veins. Simple veins are located near the skin. (After: Scholander and Schevill, 1955).

Centigrade below that of man. There was very little temperature drop along the peduncle. At the base of the tail it was still 34.2°C one and a half hours after death, in spite of a sea temperature of 12°C. The countercurrent system in the fin whale exists through the latter three meters of its body. Since there was only about a one degree temperature drop along this system, it does not seem to function as a heat exchanger in a large whale, and yet a quiet animal such as this one was should have the most need to conserve heat. There was a surprisingly high temperature well out in the fluke of the tail. Apparently even under conditions of minimal heat production a large whale can afford to waste the heat to keep its uninsulated tail warm.

Probably equally important was the information picked up in the galley over a cup of coffee. Men who make their living on the sea are generally shrewd observers and these were no exceptions. The Steinshamn whalers had noted that the tail fluke showed very little bleeding when an animal was killed quietly in the same manner



This diagram indicates the heat exchange system whereby the returning venous blood is warmed by the blood in the artery. (After: Scholander and Schevill, 1955).

as this one. However, if the whale had been chased for some distance and had struggled after harpooning they found profuse bleeding. This suggests that the whale increased its circulation through the tail, and probably also

the flippers, during the periods of greater heat production. This would allow larger amounts of heat to be dissipated from these surfaces. It is unfortunate that measurements could not be made on such an animal to see if one finds the expected warmer body and, in particular, higher temperatures in the tail and maybe in the flippers.

After death the bacteria in the whale start to multiply rapidly and if allowed to continue will putrefy the flesh, making it inedible. Since this process goes faster at a higher temperature an effort is sometimes made to provide cooling by cutting open the belly and allowing the cold sea water to circulate into the abdominal cavity. Thus it seemed worth while to see what effect this has on the temperature in the rest of the animal. The temperature in various parts of the whale was followed during the 24 hours necessary to tow it to shore.

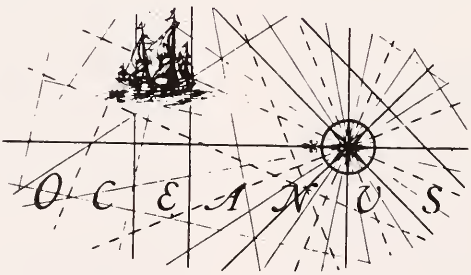
The heat in the body of the dead whale showed two features. First, the temperature in the body cavity rose at a constant rate of one-half degree Centigrade per hour. Since no, or very little, oxygen was available we can be fairly certain that this heat production was due to the growth of bacteria which are always present in large numbers in the digestive system. With the blood no longer circulating in the dead animal the heat cannot be carried away and the temperature rises.

A thermometer-harpoon left imbedded deep in the back muscle, which forms most of the edible meat, showed a temperature drop of less than one degree in 24 hours. There is apparently no additional heat produced here. This emphasizes how slow a process conduction is for losing heat, once circulation has stopped. Opening up the body turns out to be little help in preventing spoiling while the whale is towed to shore. Their large size, which is what makes them so valuable, precludes any simple way of cooling them at sea to preserve the meat.

I am placed in the position of generalizing heavily from

Dr. John Kanwisher has been at the Institution since 1953. He has been to the Arctic several times and has made studies concerning the survival of seashore animals which are exposed to freezing temperatures and ice during low tides. He has also tried to determine whether fish are important sound scatterers in the ocean.

the data on one animal, always a bad scientific policy. Within this limitation, though, I feel that mammals originally evolved into ocean dwellers as small animals, probably like present-day porpoises. The problem of keeping warm would then be much more severe and the unique anatomical structures of arteries within veins might be of more value to the animal. Then, I like to think that as whales evolved in the direction of an animal one thousand times larger the difficulty of keeping warm disappeared and these structures have remained as evolutionary relics. Such a hypothesis obviously calls for similar measurements on small porpoises. Also someone, I hope myself, should probe some more temperatures in large whales where much remains to be learned. As is usually the case, this investigation is producing more new problems than final answers.



Endowment Gift

The first addition to the Institution's endowment fund in twenty-five years was received in January. The donors, Winifred L. Parkinson and John Parkinson, Jr., presented ten shares of stock.

It should not be overlooked, however, that certain Associates, industries, and foundations have added to the Associates' Funds, as distinguished from the endowment fund.

Currents and Tides

A series of eleven lectures in Tropical Meteorology was given last fall at the Institution by Dr. Erik Palmen, Institute of Meteorology, Finland; Dr. Herbert Riehl, Department of Meteorology, University of Chicago, and Dr. Joanne S. Malkus of our staff.

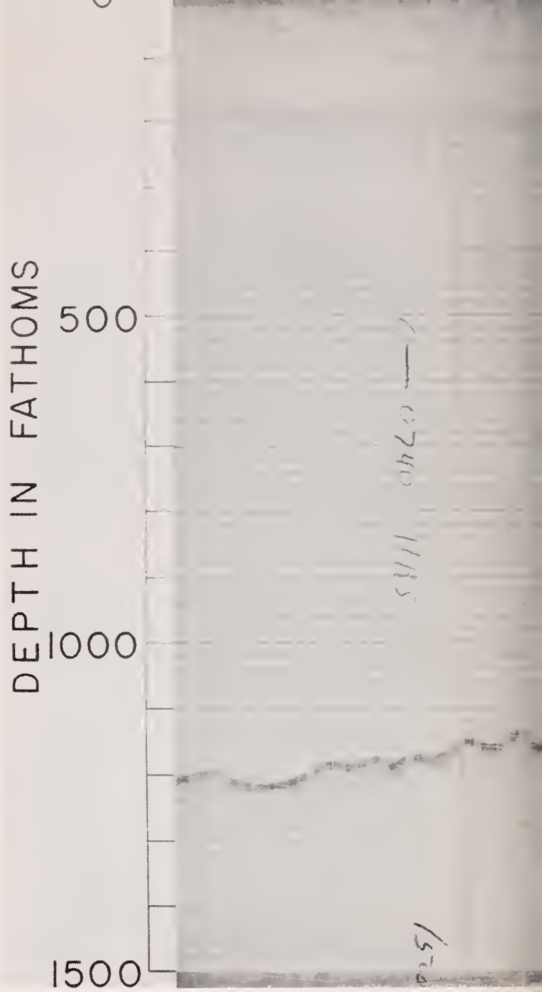
Among distinguished visitors in recent months were: Dr. E. G. Pringsheim, Pflanzenphysiologisches Institut, Gottingen, Germany; Mr. S. Wennerberg, Research Institute of National Defence, Stockholm, Sweden; Dr. George O. Curme, Jr., Union Carbide and Carbon Corp., New York City; Dr. Ken Sugawara, Nagoya University, Japan; Dr. Wolfgang Wieser, University of Washington; and Dr. F. D. Carlson of Johns Hopkins University.

A joint seminar is being held this winter between this Institution and the Massachusetts Institute of Technology. Held twice a month and alternating between Woods Hole and Cambridge, some twenty to thirty scientists, including some from Harvard University, hold informal gatherings on the general subject of thermal circulation, the basic problem of the ocean and the atmosphere. Further discussions are held during a dinner after each meeting.

The bottom of Vineyard Sound, Buzzards Bay, and other areas was well observed this winter. Dr. Harold Barnes and Arthur G. Randall of the Marine Station, Millport, Scotland, were at Woods Hole for six months to use their underwater television apparatus in conjunction with echo sounding devices of the Insitution's underwater sound group.

The PBY (Captain Norman G. Gingrass) made a second photographic beach study along the entire Atlantic and Gulf coasts of the U.S.A. Using continuously operating time-lapse motion pictures, geologist Dr. John M. Zeigler and photographer F. Claude Ronne have flown thousands of miles to study seasonal and permanent changes of the coast lines. The work, supported by the Office of Naval Research, calls for quarterly flights from Maine to Mexico.

Three of our staff members are Visiting Lecturers at the Massachusetts Institute of Technology this winter. Dr. Williams S. von Arx taught during the Fall semester, while Drs. Joanne S. Malkus and J. B. Hersey are teaching during the Spring semester.



A sea mount in the western Caribbean Sea rises 5,400 feet above the ocean bottom. A remarkable feature are the foothills to one side of the mount and the level plain on the other side. Steepness of the mount is greatly exaggerated. The distance between the times 0740 and 0840 represents about ten miles.

Oceanus goes to the bottom

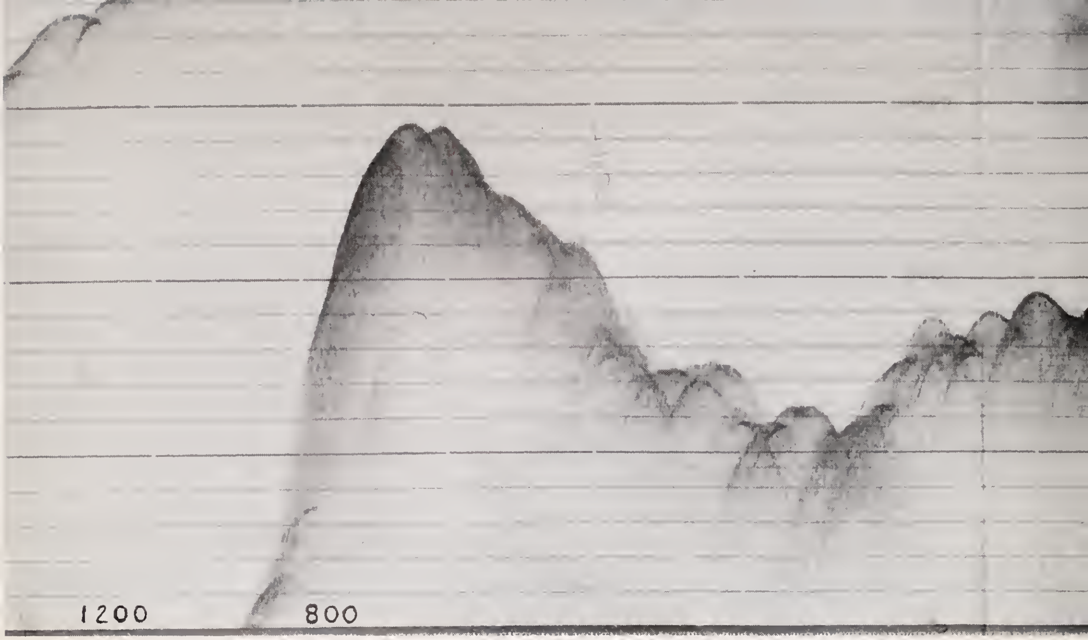
THE ocean bottom has a peculiar fascination; what does it look like? what is its topography? how does it form? are but a few questions arising as we think of that surface lying miles below a ship. To watch the profile of the ocean bottom unrolling on the paper of a recording echo sounder is as fascinating as observing the heavens through a powerful telescope. Moving the ship or moving the field of view of the telescope may, at any moment, reveal a hitherto unknown feature. More so in the case

of the sea.

of echo sounding, as the ocean bed still is inadequately charted.

Two years ago we described the precision echo sounder recording system developed at the Institution by S. T. Knott and others of Dr. J. B. Hersey's geophysics group*. Able to measure the sound pulse's travel time with great accuracy, this versatile system has been used extensively on many cruises of our ships and now has been developed to the

* See: New Instruments, Oceanus, Vol. III, No. 2

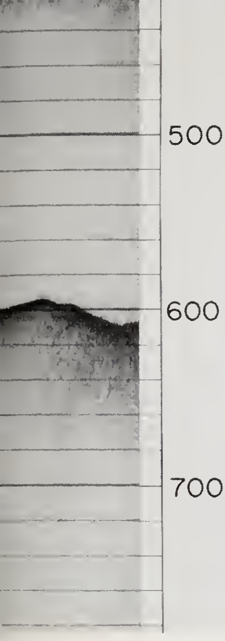


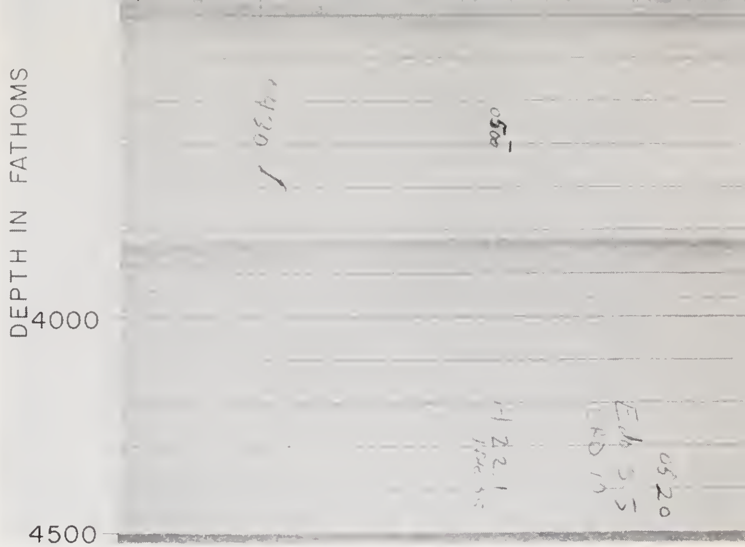
Four hundred fathom interval recording shows how correct depth has to be marked on the paper.
The precision echo-sounder recording system has some 16 speeds available, ranging through a wide selection of depth intervals from a 20-fathom sweep to a 4,000-fathom sweep.

extent that the rather alarming appearing apparatus can be operated by someone who is not an electronic wizard. Spewing out reams of paper, the apparatus cannot be left alone very long. Times and positions must be marked, as well as ship's heading, cruise number, date, etc. No amount of trouble, however, can take away from the utter enchantment of watching an unknown moutain arise before one's eyes. Although the echo sounding trace does not show us the actual contours, the colors and the full view, this is what the pathfinders of the West must have felt as they encountered new mountains. Oceanographers are lucky in that they do not have to scale theirs.

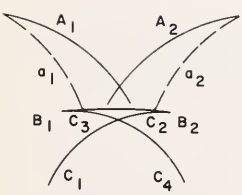
A paper on the Woods Hole recording system has just been published, see: S. T. Knott and J. B. Hersey, 1956, "High-resolution echo-sounding techniques and their uses in bathymetry, marine geophysics, and biology", Deep-Sea Research, Vol. 4, No. 1, pp. 36 to 44.

Up, down or level, the sea bottom is recorded.



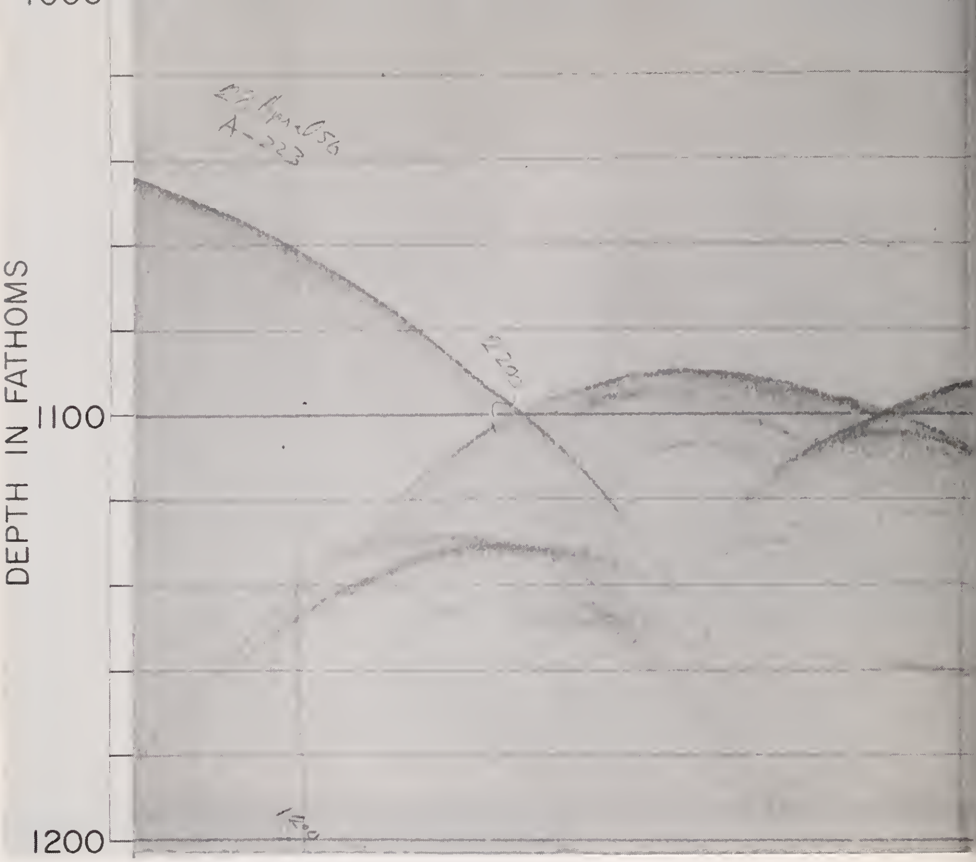


Vast areas of the sea bottom form smooth, level plains, generally at depths from 2,800 to 3,200 fathoms (16,800 to 19,200 feet). For instance five million square miles of the Pacific Basin, equivalent to the areas of China and India, is smooth. Geophysicists, first enthusiastic about the newly discovered roughness of the ocean bottom, now have become intensely interested in these great level areas.



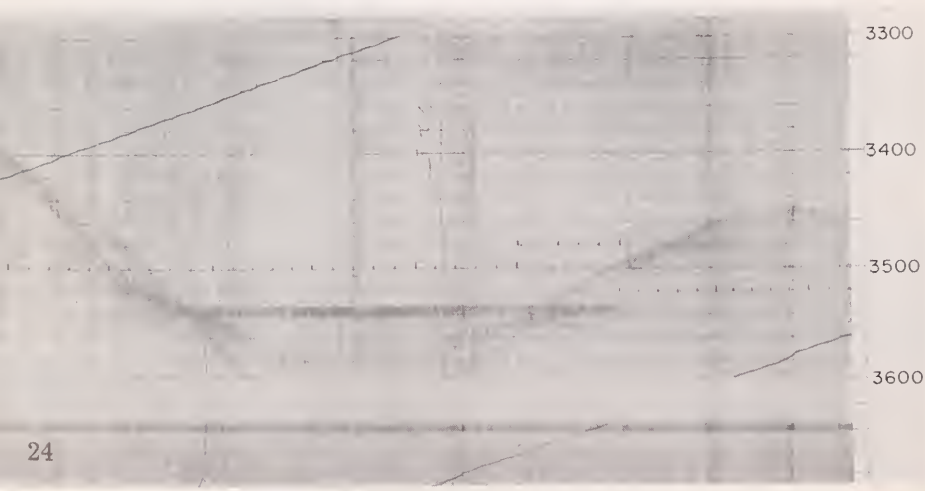
Dashed lines may represent canyon walls.

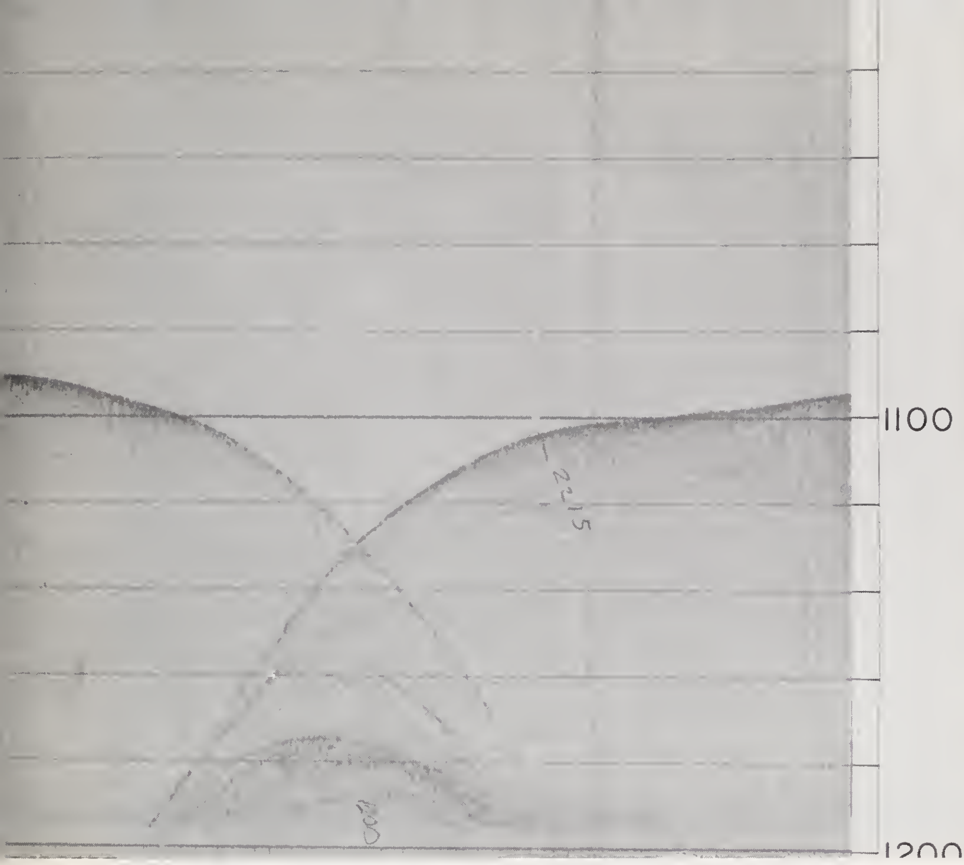
This recording of a submarine canyon, at a depth of 470 fathoms, shows clearly how the broad sound cone may be reflected from some distance up or down the slope or from the sides. The heavy line in the middle represents the flat bottom of the canyon, hence the shape of the canyon is more like a wide-bottomed V. The inverted Λ under the flat bottom is caused by highlights from the corners of the canyon bottom as the ship approached and passed.



These crescent shapes do not represent the true shape of the bottom. Because of the wide angle of the sound beam, sound is reflected from points on the sides of rugged terrain. These reflections may arrive at the echo sounder before the

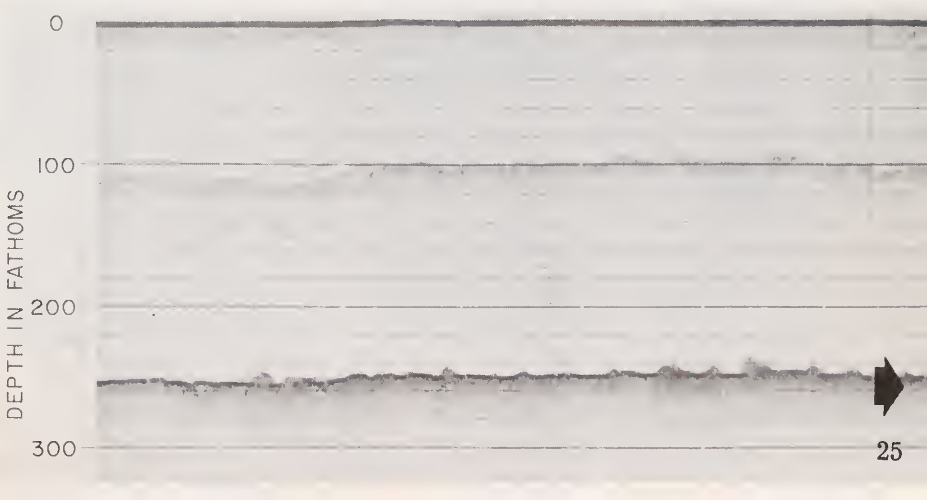
Flat bottom of the Oriente Deep south of Cuba, at a depth of 3,535 fathoms (21,150 feet). Many of the deeps and trenches which have been charted by modern methods show a flat bottom surrounded by extremely rugged topography.
The diagonal lines are timing lines made by a chronometer attached to the precision echo-sounding recorder.





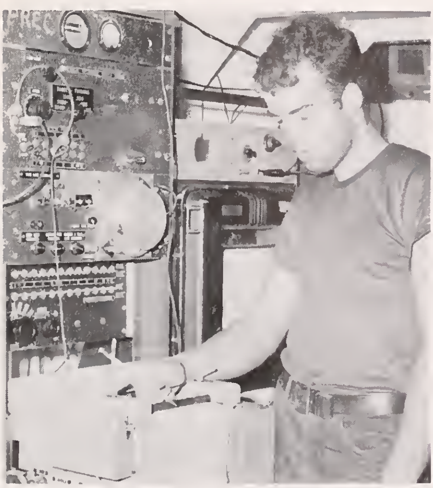
echoes from the bottom directly below the ship. The multiple echoes received from the bottom sometimes make interpretation of the records difficult.

Small bumps about six to fifty feet high on the bottom of the Florida Straits have been found under the Florida Current on various cross sections. It is not yet known what they are and what they signify. The second bottom reflection is shown at about 100 fathoms on this trace. Horizontal lines represent 20-fathom intervals. A timing device breaks the lines every five minutes.



Echo sounding has been used for more than twenty-five years as an aid to navigation in shallow water. As the commercial echo sounders were developed it became possible to obtain deeper and deeper soundings while the old system of depth indication by light flashes on a graduated scale evolved into continuous recording on paper. Some notable investigations were made in the early 1930's by the U. S. Coast and Geodetic Survey while charting the New England canyons, but it was not until after World War II that our ships and other oceanographic vessels were fitted with continuously recording sounders, able to record the bottom at thousands of fathoms below the sea surface. This resulted in changing the concept of the ocean botom as a generally level plain broken only by occasional mountain ridges, deeps and trenches. New sea mounts, canyons, deeps, faults, even mountain chains in the Pacific Ocean, were discovered, while inadequately known features were charted in detail. Geophysicists soon found that the recording of commercial echo sounders was not sufficiently precise for their scientific requirements. Both at Columbia University's Lamont Geological Observatory and at the Woods Hole Oceanographic Institution precision recording equipment was developed to obtain a better knowledge of the hidden sea floor. Echo sounding together with seismic refraction and reflection "shooting" now have evolved to the point where the presence of the water column makes certain observations easier to obtain than similar ones on land.

Deep underwater photography developed also into a practical art and soon will be more and more useful to marine geophysics and marine biology. On the following pages we have included some examples of the use of self-contained undersea cameras.



The Woods Hole precision recording system uses Alden facsimile recorders and can be connected to Edo, Raytheon, or other echo sounders.
The array of switches, buttons, and dials are viewed with equanimity by summer student Conrad Malicoat on board the R. V. "Crawford".

D. M. Owen

A deep-sea camera lowered from the "Atlantis provided this view of a steep cliff rising 7,200 feet from the sea bottom off the west coast of Florida.
Taken at a depth of 6,600 feet, the photograph shows in the foreground a crinoid or sea lily. Several gorgonians are also shown (crinoids and gorgonians are animals, not plants).

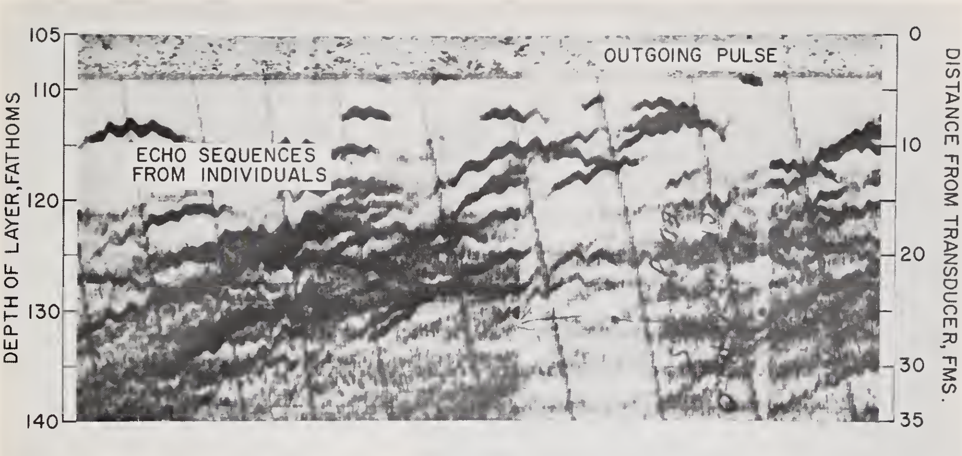
A "view" of Hudson Canyon illustrates continuous operation on the 500-fathom sweep. As the canyon deepens the bottom is recorded on the next sweep and the correct depth interval has to be assigned by the operator on watch; however, note that a scattering layer occurs at about 100 fathoms and remains in the 0 to 500 fathom interval.
Arrows on vertical time-marking lines indicate exact moments in which Loran positions were obtained for accurate plotting of the data on a bathymetric chart.

Scattering Layers*

During underwater sound experiments made off California during World War II it was discovered that echoes were received from unidentifiable targets at mid-depths. Named the scattering layer it was soon determined that such a layer could be recorded on echo sounders. This can be seen on many of the records reproduced here. Many investigators at many laboratories since have studied this phenomenon which is not yet satisfactorily explained. Early in the investigation it was found that the layer moved down at sunrise and toward the surface at sunset. Other layers at various depths were discovered, some of which remained at one level or went down instead of up at sunset.

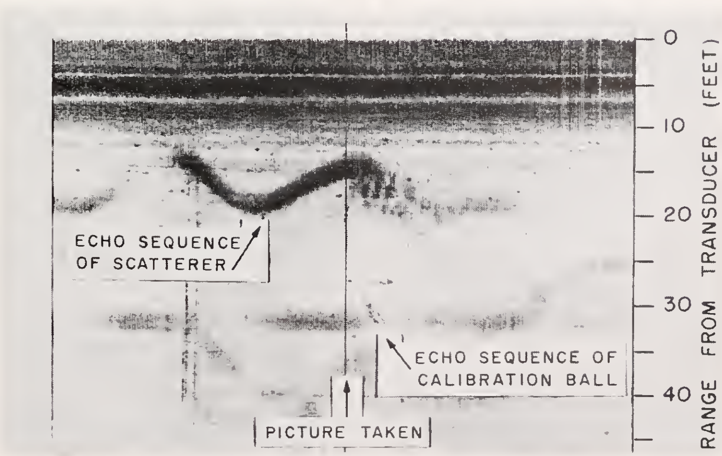
What are they? Numerous hypotheses were formed; the movement of the layers pointed to a biological origin, apart from the fact that no evidence of physical or chemical anomalies, which also might scatter sound, was found. Euphausiids — tiny shrimplike animals — squid, larval fishes, and deep-sea fishes were all considered as likely causes for the scattering. Many studies have been made, both by using underwater sound of varying frequencies and by mid-water trawls, whose content do not necessarily show which animals were scatterers. By combining an underwater camera with acoustical apparatus our scientists have been able to nab some of the culprits.

* See: Sound in Marine Research, Oceanus, Vol. III, No. 1.



Sound scatterers in the sea appear as a mass of individual crescents when an echo sounder is close to the scatterers. The crescent shape is due to the relative movement between the ship and the scatterers.

Photograph and simultaneous acoustic record of eight unidentified fishes at a depth of 100 feet in 6,000 feet of water (After: Johnson, Backus, Hersey, and Owen).



Working up the data takes time.

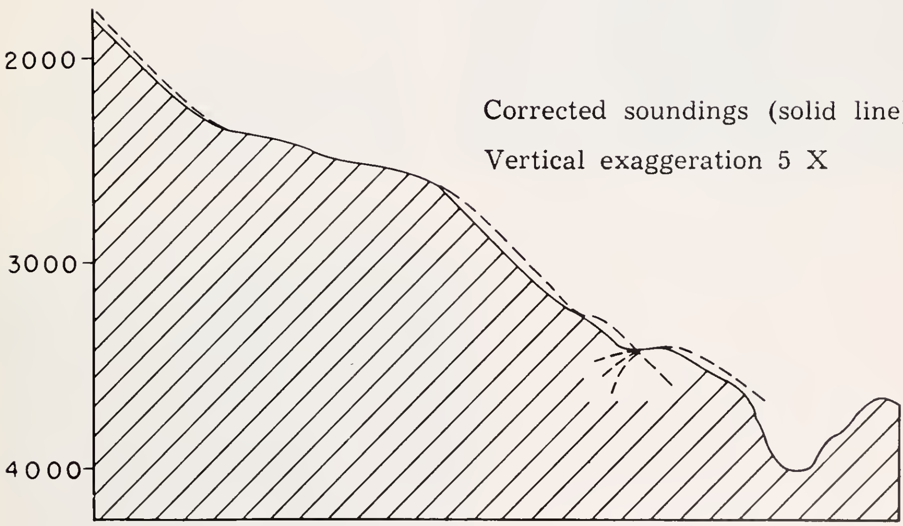
After many cruises to help collect the data, Charles S. Innis and William M. Dunkle are plotting ship's tracks and soundings on an overlay prior to the drawing of a bathymetric chart.

What happens to the hundreds of feet of recording paper representing thousands of miles of ocean bottom? Some of the records, depicting new features or detailed surveys, are published directly in scientific papers. For the making of bathymetric charts many steps are necessary since the records do not represent the true depth. The velocity of underwater sound, about 4,900 feet per second, is influenced by temperature, salinity, and pressure changes. Hence, tables have been developed to make the necessary corrections, depending on locality and availability of hydrographic observations.

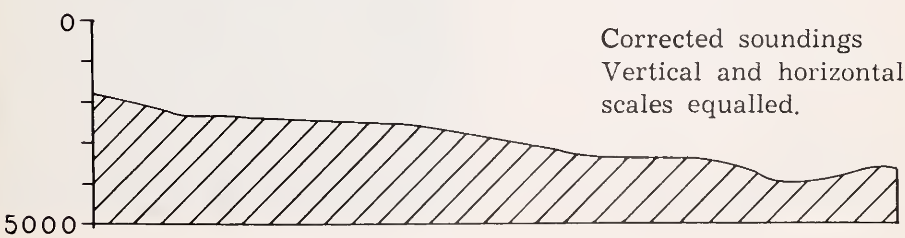
To obtain true depths in areas of rugged topography, such as the Peru-Chile Trench where echoes are received from a wide area thereby confusing the record, slope correction techniques may be applied. The vertical exaggeration of the original sounding records is indicated by the illustrations on the next page prepared by H. Small of our staff for a paper on the work done by the "Atlantis" on the South Pacific cruise made in 1955-56.

Accurate plots are being made on chart overlays with the aid of Loran or celestial observations and, finally, after much plotting of many overlapping tracks, a bathymetric chart may be produced.

Actual soundings. Note multiple echo surfaces.



Corrected soundings (solid line)
Vertical exaggeration 5 X



Corrected soundings
Vertical and horizontal
scales equalled.

The "Meteor" on station in the South Atlantic in 1926. Many of the "Meteor" observations will be repeated during the IGY.

Oceanographer L. V. Worthington taking one of a series of Nansen bottles off the wire.

Deep Water

DURING recent years the deep circulation of ocean water has aroused more and more interest among oceanographers. A knowledge of the "turnover" rate of the vast masses of deep ocean water is of vital importance for the study of climatic trends. An understanding of this circulation might lead to a knowledge of the mild or severe climatic fluctuations which have taken place since the last glacial age, while it would, of course, be of great importance to have a foreknowledge of climatic changes. Also, there is but a short time left to decide whether the ocean or parts of the ocean can be used safely for the disposal of atomic wastes. Measurements of the decay of radiocarbon^{14} and of the consumption of oxygen in deep water have led to radically different estimates on the age of deep water. A time difference of roughly 1,500 versus 150 years has to be reconciled.

Oceanographer L. V. Worthington of our staff has made many cruises for this purpose during the last few years and just before Christmas returned on board the "Atlantis" from a seven weeks' cruise between Newfoundland and the West Indies. He remains convinced that the deep North Atlantic Water, as well as the water in the Caribbean Sea, was formed during the cold period of "winter without summer" between 1810 to 1830.

The interest in deep ocean water was emphasized at a Symposium on Aspects of Deep-Sea Research held at Washington last February. The papers read there are to be published together and are edited by Dr. Wm. S. von Arx of our staff. Another symposium will be held at Toronto in September 1957 for the International Association of Physical Oceanographers. Oceanographer Henry Stommel of our staff was honored by being asked to plan this symposium.

The Meteor

In the years 1925-1927 the German Navy vessel "Meteor" made a classic survey of the South Atlantic Ocean. A recent re-evaluation of the observations showed that South Atlantic bottom currents are not insignificant. This Institution invited Dr. Georg Wüst of the Institution für Meereskunde of Kiel University, Germany, to come to Woods Hole last October. Dr. Wüst, who became the leader of the "Meteor" expedition after the death of Dr. A. Merz, presented a series of three lectures concerning the current velocities in the Atlantic deep

sea and the mass transport of water on both sides of the South Atlantic Ridge.

Many of the hydrographic observations made by the "Meteor" will be repeated during the IGY. On January 28th the Research Vessel "Crawford" (Captain David Casiles) departed Woods Hole for a four months' cruise in the South Atlantic Ocean under the leadership of oceanographer F. C. Fuglister. The cruise was planned both as a start for work to be performed during the IGY and also to determine if the small 125-foot "Crawford" is able to perform the work hitherto made from larger vessels.

We would like to mention that Dr. Wüst, during his stay at Woods Hole, obtained a reputation as a raconteur. He told many wonderful anecdotes obtained in a lifetime of oceanographic acquaintanceships. One of the most wonderful stories, according to Milton Rutstein who collected them, concerned Dr. Anton Fr. Bruun, leader of the Danish "Galathea" expedition. Dr. Bruun, who, with others, firmly believes there are very large animals in the sea never taken by man, announced that one of the purposes of the "Galathea" expedition was the collection of sea monsters. One day a seaman saw a monster and ran to Bruun asking him to come quickly on deck. Bruun hardly moved at his desk — slowly reached for his glasses, looked up to the seaman and said, "Do you think that I will go on deck to see this sea serpent and be called a liar for the rest of my life? No sir! I will stay right here in my cabin."

Captured shark (**Carcharhinus leucas,** cub or whale shark) biting line.

We hope none of our readers was this angry while anxiously awaiting the autumn 1956 issue of "Oceanus". The editor was at sea on the "Crawford" and decided to combine the autumn and winter issues.

The Sounds of Fishes

By James M. Moulton

Sound is so well transmitted through sea water that it is not surprising that nature should have provided many fishes with elaborate sound producing and receiving devices.

THE long debated question: whether or not fishes hear, was finally settled in 1904 by Dr. H. B. Bigelow when he demonstrated that severing of the auditory nerves in the goldfish eliminated responses to sound. Since that time, by a variety of methods, the hearing ability of several species of fishes has been verified and at least partially measured. While there are still many questions to be answered, it seems clear from the work of G. H. Parker, of Karl von Frisch and his school, of Vilstrup and others that the inner ear is responsible for most of a fish's ability to hear. However, it is quite possible that lower frequencies are "received" by fishes through the sensitivity to vibrations of their laterial line organs, and perhaps of isolated skin receptors. There is no longer any doubt that fishes do hear, and that their hearing capacity is centered in the inner ear.

What is there to hear in the sea? It has been known for more than two thousand years that various kinds of fishes are capable of producing sounds. Aristotle, Pliny, Pherecrates, Athenaeus and the Greek Anthology all contain references to the sounds of fishes, Aristotle having pointed out that the sounds of fishes could not be likened to the voices of animals possessing a larynx because of the basic differences in the means of sound production.

The matter of fish sound production received relatively little attention from biologists until the time of World War II, although as long ago as 1888, G. G. Goode had suggested that the calls of the drums were doubtless a means of communication between the sexes. By 1910, C. F. Holder and David Starr Jordan had predicted that some day the calls of fishes would be recorded "into a phonograph for the benefit of

posterity." Some important studies on the mechanisms of fish sound production had been made, but the field was largely unexplored when early in World War II the sounds of fishes, as well as those of marine mammals and crustaceans, became a real problem. Underwater listening for enemy ships, made possible by rapid advances in electronics, demonstrated abruptly that the oceans were not the silent places they had been assumed to be.

Sound Production

Information on sound producing marine species has accumulated rapidly here and abroad since World War II, especially in the United States through the efforts of Dr. Marie Poland Fish of the Narragansett Marine Laboratory of the University of Rhode Island. It is evident that the species of fishes who have the anatomical adaptations apparently specialized for sound production must be numbered at least by hundreds, and among and beyond these lie many kinds which through noisy habits of eating or other behavior contribute to underwater sound. In addition to fish sounds now recognized, many sounds have been recorded at considerable depths in the ocean, notably by Dr. J. B. Hersey and his group at the Institution, and have been tentatively ascribed to fishes simply because it is difficult to imagine other kinds of organisms that might be making them.

Specializations for producing underwater sounds are as numerous as one might expect from the highly varied adaptations of fishes generally. Some fishes, the sea robins, for example, produce sounds by drumming on the sides of an internal air bladder with special drumming muscles built into the bladder walls. Other species use rapid vibrations of body wall muscles to create a resonated sound within the air chamber. Many of the trigger fishes have a small area just above the base of each pectoral fin where the air bladder, elsewhere lying deep within the body, comes close to the skin; at times of distress the fins thump on this small, taut drumhead. Still other species such as the jacks have special adaptations of the internal skeleton which allow for stridulation noises, while other forms may articulate more superficial parts — the head plates in sea horses, and pharyngeal or maxillary and mandibular teeth, for example. In several cases where sound production is by stridulation, the shrill creaking noise occurs in such a position that the resultant sound is resonated by the air bladder; the stridulation of the pharyngeal teeth in the grunts furnishes a good example.

Hearing

The fact that so many species of fish produce sound seems to imply that sound is an important factor in their way of living. Also suggestive are the hearing arrangements

in many species. While in many kinds of fishes the inner ears are isolated within the skull, others possess such intricate anatomical adaptations between the air bladder in its capacity as a resonating chamber and the inner ear that it is inferred that such elaborate equipment must be of some use. The catfishes and their relatives, the squirrel or soldier fishes and the elephant fishes of Africa, are among the latter group.

Despite anatomical and physiological evidence that fishes are sensitive to sound, despite the wide distribution of sound production among fishes, and despite the fact that all species of fishes thus far tested can be conditioned to respond to sounds within their respective hearing ranges, it has not been clearly demonstrated that sounds play an important role in the lives of fishes in nature. Attempts to make consistent alterations in the movements of fishes in nature by man-made sounds have resulted in little more than initial startle reactions or quickened swimming. Fishes are highly adaptive animals and stimuli such as sounds, odors, electric shock, pressure and salinity changes which initially cause some change in behavior may during subsequent trials have no obvious effect.

Sound Reasons

During recent years some evidence has accumulated, mainly from observations on free fishes, that certain patterns of fish behavior characteristically include the production of sound, that some fish sounds may be responses to other sounds, and that fishes may orient to sounds in more subtle ways than most of us had anticipated.

A recent publication by the author and Richard H. Backus on the effects of man-made sounds on fish movements pointed out the lack of evidence for the consistent influencing of fish movements by sound, other than in conditioning experiments. There are exceptions. During 1954 and 1955, I discovered accidently at Woods Hole that it is possible to initiate and suppress the calling of sea robins with artificial sounds during the breeding season of those fishes. Experiments with menhaden and butterfish have indicated that it may be possible to predict the paths or behavior of fishes within sound fields, that the behavior of different species may vary considerably, and that some of the observable movements of fishes within sound fields may be more than simple startle reactions. Kleerekoper has observed that conditioned creek chub follow definite paths in approaching a sound source, paths which are related to sound intensities.

Dr. James M. Moulton, Assistant Professor of Biology at Bowdoin College, is Associate in Marine Biology on our staff. He is especially interested in the sounds of fishes and their relation to fish behavior and is making pioneering studies in this field.

Many different species of fishes, notably croakers, drums and sea robins, develop calls during the breeding season and, among the croakers and drums, sexual differences in the calls are apparent. Many species of fishes produce characteristic sounds under certain conditions, such as duress, that are probably not produced at other times—the grunt of the sea robin, the fin flutter of the trigger fishes, the barking of the squirrel fish and groupers, the whine of the angelfish. It is unfortunate that for any observations of fishes at sea an unnatural factor is introduced into the environment in the person of the observer and his conveyance; however, some observations of interest have been obtained at sea. Thus Griffin has analyzed a call and its echo, tentatively ascribed to a fish, recorded from the CARYN in deep water one hundred miles north of Puerto Rico, and has suggested the possibility that a fish might have been using an echo-location device at a level below that of light penetration. Last summer at the American Museum of Natural History's Lerner Marine Laboratory at Bimini in the Bahamas, I watched the behavior of grouper and squirrel fish through a face plate and from glass-bottom boats over the reefs, as these fishes eyed an approaching hydrophone, barked sharply in its direction and then turned to dart into holes in the reef. I also watched a twelve-inch black angelfish nibbling at the hydrophone, suddenly give vent to its whining cry and swim away to an approaching fish of the same species, continuing to call as the two fish faced each other for a few seconds. Finally, both came quietly to the hydrophone as if to examine it.

Making a picture of sound. The noise of this sea robin and other animals are made visual by summer student Diane Pardoe working the frequency vibration analyzer.

Sound Fishing

Unaware of the scarcity of experimental evidence that the activities of fishes are in-

fluenced by sound, several fisheries, especially in Asia, have long utilized sound to improve the catch. Ryukyuan fisherman use 'scare ropes' in dragging metal rings over the bottom, and 'sound tubs' to create a pounding on the surface. These, in conjunction with swimming fishermen, are thought to scare fishes from crevices and toward the nets.

In Bontang, Mahakam, East Borneo, a limited fishery uses a 'kuruck-kuruck'—a triangular bamboo frame with coconut half shells strung along one side of the triangle. The fishermen are convinced that when this is shaken under water by means of a short handle, certain kinds of fishes are attracted to hooks hung from the boat.

On our own west and east coasts, herring fishermen, pounding with a heavy wooden mallet on the deck of the fishing boat at night, can spot the location of herring schools as the startled fish cause myriad small luminescent animals to glow. The habit of menhaden and herring fishermen of striking the water or boat with oars during the closing of a seine to frighten the encircled fish from the still open gap, has its counterpart in a Malayan fishery in the thrashing of an ornamented pole stuck into the water in front of a large seine, the noise being believed to frighten fishes into the pocket. The method is also reflected in 'blashing'—a restricted salmon and sea trout fishery of Robin Hood's Bay, Yorkshire, England, of which I am informed by Dr. John S. Colman. Here, fishermen create a loud noise while rowing parallel to the shore at night, afterward placing a seine around the area between shore and their course, the ends of the seine being hauled in from shore. "The point is," writes Dr. Colman, "that the men believe that the noise of blashing scares the fish and that any fish between the boat's course and the sand rush into the shallow water away from the noise, where they are rounded up in the subsequent haul of the seine net."

Sounds made by the fish also are utilized in some fisheries. In India and in Indonesia the presence of edible sound producing species is detected by listening at one end of a pole running from the water to the ear in the nature of a stethoscope. Indeed, around the shores of the warmer areas of the world, fish sounds are a familiar component of the fisherman's experience and these sounds are used as an indication of good fishing as far north as Japan. The art of fish listening reaches its highest refinement in Malaya in the net leader fish listener, or juru selam. Although in modern times these fish detecting specialists have taken to the wearing of goggles as a visual aid, in years gone by the placing of the net was guided through listening only. Mr. E. R. A. de Zylva has written me of a conversation with a Malayan fish listener who not only affirmed that while swimming he could

recognize by ear the species and number of fishes present, but that he derived much additional information as to the activity of nearby fishes through listening, explaining his power as follows: "When you are walking in the sun and pass into the shade of the forest you feel a difference on your skin." Other natives regard the experienced Malayan fish listener with awe and he is reputed to be immune to shark bite.

Interest to Man

Fish sounds are part of the normal behavior of many fishes, and it is likely that they play an important part in their lives. The sounds are of interest to man for many reasons; through laboratory analysis of recordings they provide a means of identification of fishes at sea which may not be seen, they provide a means of charting the distribution of sound producing species, and they may provide new insight into orientation mechanisms of which as yet we are ignorant. Most exciting of all, they suggest the possibility that eventually it may be possible to use sound to some extent to direct the movements and activities of fishes.

Track of the R. V. "Crawford" during present cruise. The ship will return about June 1st.

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